Progress Report

for the period 8/1/64 to 1/31/65

Grant NsG-366

Submitted to the

National Aeronautics and Space Administration

by Edward Anders

Enrico Fermi Institute for Nuclear Studies
Departments of Chemistry and Geophysical Sciences
University of Chicago

I. Publications

*1. Origin of the Canyon Diablo No. 2 and No. 3 Meteorites. D. Heymann. Nature 4961, 819-820 (1964).

*2. Orgueil Meteorite: Organic Nitrogen Contents. R. Hayatsu. Science, 146, 3649, 1291-1293 (1964).

3. Contaminated Meteorite. E. Anders, E. DuFresne, R. Hayatsu, A. DuFresne, A. Cavaille, F. Fitch. Science, 146, 3648, 1157-1161 (1964).

4. Search for Optical Activity in The Orgueil Meteorite. R. Hayatsu. Submitted to Nature, December, 1964, 12 pages.

II. Work in Progress

1. Canyon Diablo Meteorite

D. Heymann and B. Nielsen

This paper has been completed and is ready for typing. The abstract follows:

"In an attempt to reconstruct the history of the surviving Canyon Diablo fragments, we have studied 56 specimens by metallography and mass spectrometry, and 5 others by metallography only. Of these, 5 came from the rim of the crater, and 36 from the plains. Fifteen contained diamonds.

"On the basis of metallographically observable reheating effects, the samples were classified into strongly, moderately, and lightly shocked categories, corresponding to shock pressures of ≥800kb, 130 - 800kb, and <130kb. The division among these categories was as follows: plains: 0

*Preprints were submitted with the previous progress report.

15, and 85%; rim: 74, 26, and 0%; diamond-bearing: 67, 33, and 0%. This bears out earlier observations by Nininger and the authors that rim (and diamond-bearing) specimens tend to be much more strongly reheated than are plains specimens.

"To determine the original depth in the meteoroid from which the specimens came, we measured their He^3 content. The values vary by a factor of 10^4, ranging from $\leq 0.03 \times 10^{-8}$ to 294×10^{-8} ccSTP/g He^3. Apparently the great majority of samples come from the outermost two meters of the meteoroid. There appears to be a distinct grading of shock effects with depth: the mean depth of the lightly shocked specimens is 72 cm, whereas that of the moderately and strongly shocked specimens is 127 cm. Diamond-bearing and rim specimens also come from greater mean depths: 116 and 121 cm, in contrast to plains specimens (81 cm). The moderately-to-strongly shocked specimens, as well as the metallic spherules resulting from the vaporization of the meteorite, show a marked localization NE and SE of the crater. The throwout pattern for shocked material seems to have been highly directional, as in the case of lunar rays.

"Measurements of He, Ne, and Ar in 4 of the most gas-rich samples gave a cosmic-ray age of 940 m.y. for 2, 540 m.y. for 7, and 170 m.y. for 5 samples. Apparently the Canyon Diablo object originated in a breakup 940 m.y. ago, and suffered two secondary collisions in space 540 and 170 m.y. ago."

2. Meteorite Ages.

D. Heymann, A. Fris, and L. Levin.

The move to our new low-level counting laboratory inactivated our

counters for several months, but nearly all of them are back in operation again. During the shutdown, we made many small technical improvements to the instruments.

Good progress is being made on the dating of shocked hypersthene chondrites. Twenty-one meteorites have been measured thus far. To establish the date of the shock event with greatest precision, we are attempting age determinations on separated minerals. We are also measuring the uranium content of most meteorites.

A series of measurements on 14 amphoteric chondrites has been completed, and a paper is in the final stages of preparation. The abstract follows:

"Cosmogenic and radiogenic rare gases were measured by mass-spectrometry in 14 amphoterites in an attempt to compare their radiation ages and gas-retention ages to those of ordinary chondrites. The cosmic ray exposure ages of amphoterites vary from 0.9 - 58 m.y.

"Four amphoterites had Ar^{40} contents significantly different from Ar^{40} contents reported by others. However, the variations are not systematic and reflect, perhaps, a non-uniform K content.

"The meteorites Appley Bridge, Hamlet, and Soko-Banja have the same fall date, November 13, but very different exposure ages of 1, 31, and 55 m.y., indicating that they were not part of a meteorite swarm or stream.

"On a correlation plot of radiation age vs. gas-rentention age, the amphoterites were located in an area of their own. Although two of the meteorites had U, Th-He ages as short as 1 b.y., most others were indeed

quite old. Seventy-four percent have ages greater than 3.0 b.y., whereas only 20% of the hypersthene chondrites have ages above this limit. Perhaps a majority of the amphoterites were outgassed 3-4 b.y. ago and escaped the reheating episode which hypersthene chondrites suffered late in their history."

3. Meteorites and Asteroids

To determine whether stony meteorites are of asteroidal or lunar origin, Tisserand's criterion was applied to the orbits of 15 meteorites and non-cometary fireballs, 8 Apollo asteroids, and 34 Mars asteroids. The data point decisively to a link between meteorites, Apollo asteroids, and Mars asteroids, and speak strongly against a lunar origin.

An attempt was made to reconstruct the original size distribution in the asteroid belt, and to estimate the rates of breakup and dispersal. Again, a manuscript has been completed. The abstract follows:

"The magnitude distribution of asteroids between 2.0 and 2.6 a.u. resembles a Gaussian curve at lower magnitudes (= larger diameters), grading into a logarithmic curve at higher magnitudes. When the asteroids belonging to Hirayama families are reassembled into their parent asteroids, the Gaussian portion is enhanced at the expense of the logarithmic one. If this operation is repeated once (to allow for dispersed and unrecognized families), the logarithmic branch disappears entirely, leaving what may be the original, Gaussian distribution.

"The following conclusions can be drawn from a comparison of the present distribution between 2.15 and 2.6 a.u. with the 'original'

one:

1. The collision half-life of asteroids, for a loss of one-half their original mass, is 6.1Æ.
2. The cross-sectional area of all asteroids brighter than g = 14 has increased by only 6% during the last 4.5Æ.
3. The average crushing strength of asteroids seems to be about 2×10^8 dynes/cm^2.
4. The halflife for dispersal or destruction of Hirayama families is ≥2.2Æ.

"The original magnitudes of 13 reconstituted Hirayama families range from g = 7.4 to g = 10.1. One of the four families crossing the orbit of Mars seems to have originated in a collision 400 m.y. ago."

4. Organic Matter in Carbonaceous Chondrites

R. Hayatsu.

The purported optical activity in Orgueil was not confirmed (preprint No. 4). Synthesis of organic compounds by UV irradiation is being studied.

5. Diamonds in Meteorites

B. Nielsen.

We have finally obtained a portion of the Canyon Diablo specimen alleged to contain diamonds, but no shock effects (N.L. Carter and

G. C. Kennedy, J. Geophys. Res. 69, 2403, 1964). We found ample evidence of shock in the 600-1000kb range. Besides, the "diamonds" turned out to be chromic oxide.